Team Q's Approach to the Third Sandia Fracture Challenge

Kyle N. Karlson*, Coleman Alleman, James W. Foulk III, Kevin L. Manktelow, Jakob T. Ostien, Michael E. Stender, Andrew J. Stershic and Michael G. Veilleux

Sandia National Laboratories, 7011 East Avenue
Livermore, CA 94550, USA
Tel.: +1-925-294-2280
email: knkarls@sandia.gov

ABSTRACT

The third Sandia Fracture Challenge involved predicting failure of a complex geometry produced using additive manufacturing. Due to the geometric and material uncertainties introduced by modern additive manufacturing (AM) techniques, we approached the challenge by attempting to determine the root-cause of the observed behavior and variability for each of the challenge material characterization tests. To begin, we used optimization methods to calibrate a rate dependent and anisotropic Hill plasticity model to represent material deformation coupled with a damage model driven by void growth and nucleation. We then used simulations of the SFC3 geometries to test hypotheses about the influence of defect structures and damage on the material characterization tests results and our challenge predictions. With simulation results supporting our material modeling choices for the AM 316L material of interest, calibrations were performed to all data providing an estimate of material model parameter uncertainty. To investigate the effect of the variability of the challenge specimens' geometric features, simulations of each of the provided challenge specimen geometries were performed with the nominal material parameter set. These simulations demonstrated that the exact geometry of the challenge geometries' holes and channels strongly influenced our predictions for the SFC3 quantities of interest. With material and geometric variability in mind, we used the Kolmogorov-Smirnov test statistic to determine a reduced set of simulations to appropriately account for variability in our predictions. For this particular material and geometry, our approach provided accurate predictions for the global response of the challenge specimen and predicted the correct failure path. After the challenge, we performed a reinvestigation of the challenge using newly available test data. Our reinvestigation focused on the influence of AM material defects on our calibration results and challenge predictions by explicitly modeling pores and defects in our models. Initial results of this reinvestigation will be presented and compared to experimental results.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.